Health Behaviors at the Onset of the COVID-19 Pandemic

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Objectives: We examined perceived behavior change since implementation of physical distancing restrictions and identified modifiable (self-rated health, resilience, depressive symptoms, social support and subjective wellbeing) and non-modifiable (demographics) risk/protective factors. **Methods:** A representative US sample (N = 362) completed an online survey about potential risk/protective factors and health behaviors prior to the pandemic and after implemented/recommended restrictions. We assessed change in perceived health behaviors prior to and following introduction of COVID-19. We conducted hierarchical linear regression to explore and identify risk/protective factors related to physical activity, diet quality, and social isolation. **Results:** There have been substantial decreases in physical activity and increases in sedentary behavior and social isolation, but no changes in diet quality since COVID-19. We identified modifiable and non-modifiable factors associated with each health behavior. **Conclusions:** Negative effects indicate the need for universal intervention to promote health behaviors. Inequalities in health behaviors among vulnerable populations may be exacerbated since COVID-19, suggesting need for targeted invention. Social support may be a mechanism to promote health behaviors. We suggest scaling out effective health behavior interventions with the same intensity in which physical distancing recommendations were implemented.

Key words: COVID-19; pandemic; risk/protective factors; physical activity; diet; social isolation
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On March 11, 2020, the World Health Organization declared COVID-19 a global pandemic.[1] Profound changes due to the pandemic, including ongoing physical (or social) distancing recommendations, increases in unemployment, and therefore, changes in financial status, and exacerbated racial and class inequities, likely will have significant detrimental impact on long-term health and wellbeing. In addition to the fear, anxiety, and stress associated with disease outbreaks, the implementation of physical distancing recommendations has altered interpersonal interactions. These changes may impact health-related behaviors and have long-term implications for physical and psychosocial health, as evidence suggests long quarantines lead to poor psychological outcomes.[2]

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We used a prevention science framework to examine perceived behavior changes since COVID-19 and identify potential modifiable and non-modifiable risk/protective factors associated with current health behaviors. Modifiable risk factors have the potential to change through prevention programs (eg, self-rated health, resilience, social support). Conversely, non-modifiable factors include predisposing (ie, age, race/ethnicity) and stable (ie, sex, geographic location) factors less likely to be altered by prevention programming, yet associated with an unequal distribution and burden of COVID-19 morbidity and mortality.[3] Higher mortality rates from COVID-19 among vulnerable populations have highlighted structural and cumulative disadvantages that intensify health inequality between racial/ethnic groups. It is important to identify social determinants of health that shape individuals' opportunities and health outcomes during the pandemic. Social determinants of health can serve as key targets for prevention efforts to support positive health behaviors. Prevention science postulates individual, intermediate, and structural factors either increase the risk for adverse health outcomes, or are protective factors that mediate or moderate exposure to risk and/or decrease the likelihood.[4] We focus on health-related behaviors including physical activity, diet quality, and social isolation, which influence long-term health and reduce risk for chronic disease and mortality.[5-7]

Physical Activity

Achieving recommended amounts of physical activity is a protective factor associated with a multitude of health benefits.[8] In contrast, low levels of physical activity increases risk of chronic disease.[9] Prior to the pandemic, most adults in the United States (US) did not meet the recommended physical activity guidelines.[8] Current recommendations during the COVID-19 pandemic acknowledge the benefits of physical activity, encouraging physical activity while maintaining physical distancing.[10] With stay-at-home orders and closures of parks and fitness centers, researchers anticipate reductions in physical activity.[5]

Researchers have identified individuals that are male, younger, White, married, employed, and having high levels of social support are more likely to participate regularly in physical activity while Hispanic individuals are more likely to engage in occupational activity.[11,12] White females and older adults, as well as individuals who had lower income, experienced depression, and lived in a rural area were at higher risk of regular physical inactivity.[11,13-15] In addition, there are structural and systematic factors serving as barriers to physical activity in minority populations.[16] Life transitions associated with decreases in physical activity include changes in employment status, residence, and family composition.[17,18]

Sedentary behavior has been associated with negative outcomes, including discrete impacts on health, because of less physical activity.[19] Therefore, most characteristics positively associated with physical activity are inversely associated with sedentary behavior.[13] Similar to physical activity, sedentary behavior tends to remain unchanged throughout life stages.[18] However, if COVID-19-related restrictions become protracted, access to spaces to be physically active may decrease, time at home may increase, and participation in concomitant sedentary behaviors, such as screen time, may escalate as well.

Diet Quality

Healthier dietary patterns are associated with reduced risk for multiple chronic diseases, many of which are associated with risk of hospitalization due to COVID-19.[20] Specifically, increased fruit and vegetable consumption and decreased added sugar consumption are important characteristics of healthy eating patterns.[6] Higher fruit and vegetable intake is preventive of cardiovascular disease and cancer, inversely associated with the risk for depression, and closely related to psychological wellbeing and happiness.[6,21] Whereas the benefits of fruit and vegetable intake are important, about 75%-85% of individuals living in the US do not meet the recommended intake. Fruit and vegetable intake differs by sex, income status, geographic location, employment status, age, and is higher among women (per 1000 calories) and individuals with higher income.[22] Urban populations consume an average of nearly one-third servings more than rural populations.[23] Fruit and vegetable intake is positively associated with employment status.[24] Households without reliable access to affordable, nutritious food may be food insecure, which is a significant risk factor for low diet quality – specifically decreased intake of fruits and vegetables.[25] Whereas fruit intake increases through adulthood, vegetable intake tends to increase from 20-59 years old and then maintain throughout older adulthood.[22]

Added sugar intake is associated with the consumption of less nutrient-dense foods, and increased likelihood of dental caries, type 2 diabetes, cardiovascular disease, and risk for depression.[26-28] Lower added sugar intake may be associated with improved psychological health.[28] Between 2005 and 2010, over 70% of Americans exceeded the recommendations of less than 10% of total calories per day from added sugars.[29] Added sugar intake is higher among men, those with lower family income, and physically inactive individuals.[27,30] In adulthood, added sugar intake tends to peak in early adulthood (18-24-year-olds) and is lowest in adults 40 years old and older.[30] Added sugar intake is lowest among non-Hispanic individuals, Asian Americans, and families with higher income and education levels.[27,30]

Social Isolation

Social health encompasses the ability to form effective relationships, fulfill social roles, and adapt to the social environment,[31] and is a key component of individual health and wellbeing across the lifespan. Social health can buffer against or worsen one's ability to adapt and manage stress or the challenges of daily living and is associated with numerous psychosocial and physical health outcomes.[32] Although social connection is protective against a range of disease morbidities and all-cause mortality,[7] social isolation is a risk factor associated with depression, poorer cardiovascular health, and mortality.[33,34] Both the quality and quantity of social interactions have been associated with health and wellbeing, with quality typically the stronger predictor.[35] Positive social interactions affect physiological processes such as immune functioning and inflammation,[36,37] circulation of stress hormones,[38] and health outcomes including cardiovascular disease,[36] diabetes,[39] depression,[40] and post-traumatic stress disorder.[41]

Physical distancing measures associated with COVID-19 changed individuals' social worlds by limiting in-person gatherings, suspending or limiting operations of many social contexts, and redefining personal roles such as parents adding the role of teacher or losing the role of primary wage earner due to becoming unemployed. These disruptions to social health and wellbeing may increase risk of experiencing social isolation. Social isolation is defined as "inadequate quality and quantity of social relations with other people at the different levels where human interaction takes place (individual, group, community and the larger social environment)"[42] and has been associated with detrimental health outcomes. More specifically, this includes poor self-rated health,[43] psychosocial health,[43-45] cognitive functioning,[46] and risk of mortality.[44] Risk factors and experiences of social isolation vary across the lifespan.[47] Older adults are particularly vulnerable[43] but younger age groups are also at risk of experiencing social isolation.[48] Researchers have found that race and sex moderate the detrimental impact of social isolation. Social isolation had a greater association on all-cause mortality among Blacks, was a significant factor for death from cancer among Whites, and had less impact on cardiovascular disease for White males than other subgroups.[49]

Current Evidence of COVID-19 and Changes to Health Behaviors

The evidence suggests contextual changes implemented/recommended to mitigate the spread of COVID-19 have led to substantial changes in health behaviors. There have been negative impacts on physical activity, mixed findings for dietary behaviors, and indications that COVID-19 has contributed to psychological distress. Several international studies indicate decreases in physical activity and increases in sedentary behavior during home confinement.[50,51] Positive dietary behaviors include improving diet quality[50,52] and eating at home,[53-55] while potentially negative behaviors include increasing consumption of snacks and unhealthy foods and eating due to stress.[50,55,56] Two studies suggest negative emotional impacts of COVID-19 including distress[57] and increases in work, financial, and family stress.[58] However, data on social connection and COVID-19 indicate no significant changes in social isolation or support from January 2020 to April 2020,[59] although differences existed by age, with older adults reporting less social isolation and greater social support, compared to middle aged or young adults. These findings align with past research on psychological impacts of quarantine in previous disease outbreaks,[2] impacts on health after experiencing a natural disaster,[60] and after September 11, 2001 in New York.[61] They also illuminate changes in health behaviors during COVID-19 that may be worrisome and require further inquiry, particularly as relatively few studies have examined the psychological impact of physical distancing on health behaviors, and fewer still have used validated measures.[2]

Purpose of Study

The purpose of this study was to assess perceived changes to health behaviors before and during COVID-19 restrictions and identify modifiable and non-modifiable risk/protective factors associated with health behaviors during COVID-19. Our first research question (RQ1) was: Among adults, how have health behaviors (physical activity, diet quality, and social isolation) changed with the implementation of physical distancing recommendations? Based on the previous literature, we hypothesized physical activity and fruit/vegetable intake will decrease, and sedentary behavior, added sugar intake, and social isolation will increase. Finally, examining COVID-19 as a unique historical context, we conducted an exploratory analysis to identify modifiable (self-rated health, resilience, depressive symptoms, social support, and subjective wellbeing) and non-modifiable (demographics) risk/protective factors associated with physical activity, diet quality, and social isolation. Our RQs were: In the context of COVID19, what risk/protective factors are associated with physical activity? (RQ2); what risk/protective factors are associated with diet quality? (RQ3); and what risk/protective factors are associated with social isolation? (RQ4). As an exploratory analysis, we did not develop *a priori* hypotheses for risk/protective factors associated with physical activity, diet quality, or social isolation.

METHODS

Participant Recruitment and Procedure

We used Prolific Academic, an established method of online participant recruitment, that cross-stratifies on age, ethnicity, and sex, to obtain a representative US sample using Census Bureau population group estimates.[62,63] Individuals were eligible for this study if they lived in the US, spoke English, and were at least 18 years old. Participants were compensated $8 for completion of all 3 parts of the survey. We obtained a representative sample with 402 participants, of which 362 completed at least Part 1 and 2 of the survey and met the criteria for completing survey attention checks. There were no statistically significant differences in demographic characteristics between participants who completed at least 2 parts of the survey and those who did not. A *post hoc* power analysis indicated that a sample of 362 participants was sufficient for the planned analysis.[64]

Prior to completing Part 1, participants consented to participate in the 3-part survey. Part 1 was posted during April 21-23, 2020 and included demographic, health history information, COVID-19 and physical distancing recommendations, measures of social isolation and support, subjective wellbeing, and resiliency. Part 2 was posted during April 28-May 6, 2020 and included measures assessing eating behavior, physical activity, financial stress, and employment. Part 3 was posted during May 1-May 6, 2020. To reduce participant burden, parents of children between 18 months and 12 years old completed measures about family and child health-related behaviors and parenting dimensions while all other participants completed a dietary questionnaire.

Measures

We collected assessments of perceived health behaviors (each dependent variable) prior to the COVID-19 pandemic (retrospectively) and after COVID-19 restrictions were implemented/recommended (current), and modifiable and non-modifiable risk/protective factors (current). Participants shared COVID-19 specific information, which provided insight about awareness of local mitigation efforts and salience of the virus.

Dependent Variables

Physical activity and sedentary behavior. The International Physical Activity Questionnaire (IPAQ-SF) is a valid and reliable 7-item measure of vigorous and moderate physical activity, walking, and time spent sitting during the past week.[65,66] Participants were asked to identify the level of physical activity (vigorous, moderate, walking, and sitting) and length of time (days per week and minutes per day) in each type of activity over the past 7 days. Data were scored using the IPAQ scoring

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guidelines and calculated using the average metabolic equivalents (MET) score for each type. Total weekly physical activity in MET-minutes per week was estimated by adding the MET value for each type of physical activity. This overall score allowed us to include all types of physical activity in an overall measure, acknowledging that physical activity habits may have changed due to COVID-19. Sedentary behavior captured the total time in minutes participants spent sitting on a weekday.

Diet quality. Intake of fruits/vegetables, and added sugar was obtained using the dietary screener questionnaire (DSQ).[67] The DSQ asks participants about the frequency of intake for selected food items and beverages. Responses are then converted into cups of fruit and vegetables (excluding French fries) and teaspoons of added sugar per day using the National Cancer Institute validated scoring procedures. The DSQ has been validated across large, diverse national samples.[67]

Social isolation. We used a single indicator of social isolation: "I feel isolated from other people" (0 = Not at all to 4 = Almost always). Single-item measures can provide highly valuable information.[69] This indicator is comparable to items commonly included in national surveys that capture a global measure of perceived social isolation.[69,70] Participants were not provided a standard definition of social isolation, which allowed for the item to capture individuals' subjective experience and feelings about social isolation (eg, their perceived adequacy of companionship and social support).[71]

Risk and Protective Factors

Non-modifiable factors. Participants answered a battery of sociodemographic questions, including age, sex, race/ethnicity, employment status, relationship status, number of children in household, and geographic residence. For analytic purposes, we created dichotomous dummy variables for all variables except for the number of children in the household, which was a continuous variable. To capture differences between 3 developmental stages[72,73] with distinct features: we used emerging [ages 18-29], middle [ages 30-59], and late [age 60+] adulthood). We recoded sex (male and female; "other" was recoded as missing for 3 participants), race/ethnicity (White, Black, and other; sample size for Asian and Hispanic/Latino were small), employment (working full/part time and other), and relationship status (married/partnered vs other); for geographic residence, we created dummy variables for each category (rural, small-town/mid-size city, suburban, or urban).

Modifiable factors. Self-rated health was measured by asking: "In general, would you say your health is:" with a 5-point response scale (0 = Poor to 5 = Excellent). This single-item measure is commonly used as a reliable and valid measure of self-rated health.[69]

Resilience was measured using a 6-item scale with a 5-point response scale (1 = strongly disagree to 5 = strongly agree), with higher scores indicating higher resilience.[74] Cronbach's alpha (α) was .918.

Depression symptoms were measured using the Center for Epidemiological Studies Depression Short Form (CES-D-10) with a 4-point response scale (0 = rarely or none of the time to 3 = all of the time).[75] The total score was calculated as the sum of the 10 items, where scores ≥ 10 indicates the presence of significant depressive symptoms ($\alpha = .866$).

Participants completed the Multidimensional Scale of Perceived Social Support,[76] asking about support from a significant other, family, and friends. Responses (1 = strongly disagree to 5 = strongly agree) to the 12-item scale were summed into a total score ($\alpha = .940$).

To assess subjective wellbeing, participants were asked: "Taking all things together, how satisfied are you with your life as a whole these days?" and responded on a 4-point response scale (1 = not at all satisfied to 4 = very satisfied).[77]

Due to the abrupt disruption to household income experienced since COVID-19 we used food security and personal financial wellbeing as proxy-indicators for financial security. Food security (binary) was based on a validated 2-item food insecurity screening tool [78] that captured participants' responses of "sometimes" or "often" true to at least one of the items. Using the 8-item Personal Financial Wellbeing, participants indicated their level of financial distress; an average score was calculated with higher scores indicating higher financial wellbeing [79] Reliability was high ($\alpha = .922$).

Data Analysis

First, we conducted univariate, bivariate, and de-

Table 1
Characteristics of the Representative Sample (N = 362)

Non-modifiable Factors	*M (SD)*	*N (%)*
Age Categories		
Emerging Adulthood (ages 18-29)	23.9 (3.4)	71 (21.5)
Middle Adulthood (ages 30-59)	45.4 (9.4)	189 (52.2)
Late Adulthood (ages 60+)	65.7 (4.8)	94 (26.0)
Sex		
Male		173 (47.8)
Female		186 (51.4)
Race/Ethnicity		
White, non-Hispanic		249 (68.8)
Black		42 (11.9)
Asian		27 (7.5)
Hispanic/Latino		20 (5.5)
Other		22 (6.1)
Marital Status		
Single		125 (34.5)
Married/Partnered		185 (51.1)
Divorced/Separated		49 (13.6)
Other		3 (0.8)
People in the Household (1-11)	2.6 (1.4)	
Number of Children (0-5)	0.3 (0.8)	
Children (binary)		
No		296 (81.8)
Yes		66 (19.2)
Geographic Location		
Rural		71 (19.6)
Mid-size city/town		36 (9.9)
Suburban		174 (48.1)
Urban		81 (22.4)
# Chronic Condition [a]	1.2 (1.4)	
Education level [a]		
≤ High School/GED		41 (11.3)
Some college		97 (26.8)
Associate Degree		47 (13.5)
4-year Degree		122 (33.7)
Graduate Degree		53 (14.6)
Current Employment		
Unemployed		79 (21.8)
Employed (Full/Part Time)		187 (51.7)
Not Seeking Work		89 (24.6)
Income/Year in 2019 [a]		
< $35,000		108 (29.8)
$35,000 – $51,999		80 (22.1)
$52,000 – $73,999		66 (18.2)
$74,000 – $99,999		52 (14.4)
> $100,000		49 (13.5)
Modifiable Factors	*M (SD)*	*N (%)*
Self-rated Health (0-3)	1.3 (0.9)	
Poor/Fair		61 (16.9)
Good		151 (41.7)
Very Good		118 (32.6)
Excellent		32 (8.8)
Resiliency (1-5)	3.4 (0.9)	
Depressive Symptoms	11.1(6.3)	
Not at Risk of Depression [b]		150 (41.4)
Depression Risk [b]		210 (58.0)
Social Support (12-60)	45.0 (11.0)	
Subjective Wellbeing, Prior to COVID-19 (1-4)	2.9 (0.8)	
Not At All Satisfied		13 (3.6)
Not Very Satisfied		94 (26.0)
Satisfied		177 (48.9)
Very Satisfied		78 (21.5)
Subjective Wellbeing, after COVID-19 restrictions (1-4)	2.6 (0.8)	
Not At All Satisfied		28 (7.2)
Not Very Satisfied		130 (35.9)
Satisfied		172 (47.5)
Very Satisfied		32 (8.8)
Food Security, Prior to COVID-19		
Food Secure		228 (63.0)
Food Insecure		87 (24.0)
Food Security, after COVID-19 restrictions		
Food Secure		221 (61.0)
Food Insecure		140 (38.7)
Personal Financial Wellbeing (1-10)	5.6 (2.1)	

(continued on next column)

Note.
Total N (%) may not add up due to missing data
[a] Included for descriptive purposes only
[b] Based on CES-D Short cutoff

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Table 2
Evaluating Health Behavior Changes

Outcome	Pre COVID-19 M(SD)	Current M(SD)	t-test	p value	Effect size
Total METs (per week)	2205.0 (3342.7)	1616.3 (2176.6)	4.828	< .001	0.27
Sitting (minutes per day)	460.9 (281.6)	494.5 (211.5)	-7.178	< .001	-0.46
Vegetables/Fruits (cups)	2.4 (0.7)	2.4 (0.7)	0.555	.580	0.03
Added Sugar (tsp)	16.4 (6.7)	16.0 (6.5)	1.258	.209	0.07
Social Isolation (0-4)	1.1 (1.1)	1.6 (1.3)	-7.692	< .001	-0.40

scriptive statistics to characterize the study sample; t-tests were used to assess changes in food security status and subjective wellbeing after COVID-19 restrictions were implemented/recommended. Then, we ran t-tests to assess perceived change (RQ1) in physical activity, diet quality, and social isolation variables from pre-COVID-19 to current. Finally, data were analyzed using hierarchical linear regression (RQ2-4) to identify risk/protective factors for physical activity (total METs, sitting), diet quality (vegetables/fruits intake, added sugar intake), and social isolation. Each model contained 2 steps: (1) a step containing relevant non-modifiable, and (2) a step that added modifiable factors. To determine if each step improved the model fit, we used the F statistic assessing significance of R^2 change. As this was an exploratory study, we included different factors in each model, based on theoretical reasons identified in the literature, statistically significant correlations (see Online Resource: Correlation Matrices), and factors likely to be relevant to circumstances related to COVID-19 (ie, age category, self-rated health, resilience, depressive symptoms, social support, and subjective wellbeing). We used pairwise deletion so all cases with available data were included in the model, regardless of missing values for other variables. Other than planned missingness on the diet quality measure, missingness was not an issue. Data were analyzed using SPSS version 26, with a p-value ≤ .05 to indicate statistical significance.

RESULTS

Sample Characteristics

Table 1 shows descriptive characteristics of the study participants. On average, emerging adults were 23.9 years old, middle-aged adults were 45.4 years old, and older adults were 65.7 years old. There were near equal number of men and women who completed the survey, with the majority identifying as non-Hispanic White. More than half of the sample was married/partnered and 19.2% had at least one child in the household. There was an average of 2.6 people per household. The majority of participants were employed full or part-time, though 20% were seeking employment. Table 1 provides additional descriptive statistics about non-modifiable and modifiable factors.

As for modifiable factors, overall the sample self-rated their health as good, very good, or excellent, although one in 6 people reported poor/fair health. Resilience scores were slightly lower than average[74] and personal financial wellbeing aligned with national average norms;[79] however, more than half the sample exhibited significant depressive symptoms (ie, at risk of depression). More than one-third of participants indicated they were food insecure, which increased significantly after COVID-19 restrictions were implemented/recommended, t(315) = -4.07, p < .01. Although descriptive findings for current subjective wellbeing suggested more than half the sample was satisfied or very satisfied, subjective wellbeing decreased after COVID-19 restrictions were implemented/recommended, t(361) = 8. 698, p = .041.

As for COVID-19 mitigation efforts, nearly all participants indicated at least one restriction was in place, with more than 90% indicating recommendations to avoid social gatherings, remain physically distant (ie, at least 6 feet apart) from persons outside the household, and leave the house only for essential reasons; most participants indicated that

Table 3
Risk and Protective Factors Associated with Physical Activity

		Model 1: Total METs (N = 259)			Model 2: Sitting (N = 298)		
		R^2	ΔR^2	F change	R^2	ΔR^2	F change
	Step 1 [a]	.059	.033	2.244*	.036	.023	2.771*
	Step 2	.152	.100	3.360**	.124	.091	4.116**
		Beta	**p value**	**95% CI**	**Beta**	**p value**	**95% CI**
Non-Modifiable Factors	**Ages 18-29 [b]**	.121	.120	-168.19 – 1448.81			
	Ages 30-59 [b]	.111	.152	-179.37 – 1144.72			
	Ages 60+ [b]				-.011	.847	-60.82 – 48.60
	Female [b]	-.009	.889	-582.74 – 505.33			
	Black [b]	-.156	.013	-1813.52 – -216.22	-.165	.005	-176.96 – -32.62
	Working Full/Part Time [b]	.031	.634	-419.00 – 686.53			
	# Children in Household	.131	.033	29.84 – 719.04	-.038	.514	-41.99 – 21.08
	Rural [b]	.057	.347	-391.59 – 963.31	-.060	.283	-90.80 – 26.61
Modifiable Factors	**Self-rated Health**	.124	.059	-11.40 – 639.42	-.116	.051	-57.33 – -0.11
	Resilience	.046	.543	-258.06 – 498.10	-.004	.950	-34.24 – 32.11
	Depressive Symptoms	-.115	.142	-91.80 – 13.21	.038	.592	-3.41 – 5.96
	Social Support	-.078	.244	-41.14 – 10.53	-.060	.328	-3.45 – 1.16
	Subjective Wellbeing	.011	.883	-391.76 – 455.24	-.090	.194	-62.72 – 12.78
	Food Secure [b]	.089	.158	-155.02 – 946.01	-.116	.045	-99.42 – -1.06
	Total METs	–	–	–	-.154	.009	-0.03 – -0.00
	Sitting	-.149	.018	-2.80 – -0.26	–	–	–
	Fruits/Vegetables Intake	.115	.073	-35.51– 801.15			

$^*p \le .05$ $^{**}p \le .001$

Note.
Factors were included based on theoretical and statistical reasoning and differ among models.
[a] Only non-modifiable factors were entered on Step 1. For parsimony, specific beta coefficients are presented only for Step 2.
[b] This variable is a dichotomous dummy variable compared to the reference group (eg, "Ages 18-29" compared to "all other ages" and "Female" compared to "male").

restaurants were serving take-out only. Less than half of participants (42.0%) adopted restrictions when they were announced, yet more than one-third (35.1%) had adopted the recommendations prior to implementation. At the time of data collection, 63.5% of participants had been following recommendations/restrictions for 5+ weeks.

Perceived Health Behavior Change

There were several significant perceived changes in health behaviors from pre-COVID to current behaviors. Specifically, total METs decreased (small effect size). Sitting and isolation increased (moderate effect size). The 2 diet quality variables did not change (Table 2).

Risk/Protective Factors Associated with Health Behaviors

For each model, adding Step 2 significantly increased the percentage of variance accounted for

Table 4
Risk and Protective Factors Associated with Diet Quality

		Model 3: Fruits/Vegetables Intake (N = 306)			Model 4: Added Sugar Intake (N = 306)		
		R^2	ΔR^2	F change	R^2	ΔR^2	F change
	Step 1[a]	.077	.068	8.410**	.084	.072	6.924**
	Step 2	.165	.134	3.892**	.136	.104	2.533*
		Beta	**p value**	**95% CI**	**Beta**	**p value**	**95% CI**
Non-Modifiable Factors	**Ages 18-29** [b]	-.143	.014	-0.41 – -0.05	.046	.453	-1.18 – 2.63
	Ages 60+ [b]				-.075	.201	-2.82 – 0.59
	Female [b]	-.239	<.001	-0.46 – -0.17	-.281	<.001	-5.09 – -2.20
	Urban [b]	.086	.110	-0.03 – 0.30	-.045	.413	-2.39 – 0.98
Modifiable Factors	**Self-rated Health**	.077	.197	-0.03 – 0.15	-.152	.012	-2.04 – -0.26
	Resilience	.082	.230	-0.04 – 0.16	.031	.657	-0.79 – 1.25
	Depressive Symptoms	.103	.142	-0.00 – 0.03	.136	.057	< -0.01 – 0.28
	Social Support	.173	.004	0.00 – 0.02	-.078	.194	-0.12 – 0.02
	Subjective Wellbeing	-.031	.650	-0.14 – 0.09	.076	.279	-0.53 – 1.82
	Food Secure [b]	-.097	.108	-0.29 – 0.03	.028	.645	-1.22 – 1.96
	Personal Financial Wellbeing	.052	.441	-0.03 – 0.06	-.008	.908	-0.43 – 0.39
	Total METs	.134	.015	0.00 – 0.00			

Note.
Factors were included based on theoretical and statistical reasoning and differ among models.
[a] Only non-modifiable factors were entered on Step 1. For parsimony, specific beta coefficients are presented only for Step 2.
[b] This variable is a dichotomous dummy variable compared to the reference group (eg, "Ages 18-29" compared to "all other ages" and "Female" compared to "male").

beyond the percentage accounted for by Step 1.

Regarding Model 1, as Table 3 shows, non-modifiable factors explained 3.3% of the variance for Total METs per week (Step 1). After including modifiable factors to the model (Step 2), the model explained an additional 6.7% of the variance. Sitting was the only statistically significant modifiable factor; as minutes per day sitting increased, total METs per week decreased. Two non-modifiable factors were statistically significant – being Black was associated with a decrease in total METs expenditure and as the number of children increased, so did total METs expenditure.

Regarding Model 2, in the model examining sitting behavior (Table 3), non-modifiable factors explained 2.3% of the variance (Step 1). When modifiable factors were included in the model (Step 2), it explained an additional 6.8% of the variance. Being Black was associated with fewer sitting minutes compared to all other races/ethnicities. Higher total METs expended per week was associated with fewer sitting minutes per day. Increasing sitting be-

Table 5
Risk and Protective Factors Associated with Social Isolation

		Model 5: Social Isolation (N = 353)		
		R^2	**ΔR^2**	**F change**
	Step 1[a]	.097	.079	5.322**
	Step 2	.314	.286	15.330**
		Beta	**p value**	**95% CI**
Non-Modifiable Factors	**Ages 18-29** [b]	.090	.091	-0.05 – 0.62
	Ages 60+ [b]	-.005	.924	-0.32 – 0.29
	Female [b]	.043	.363	-0.13 –0.36
	Black [b]	.145	.014	0.09 – 0.77
	White [b]	-.011	.850	-0.49 –0.40
	Married/Partnered [b]			
	# Children in Household	.066	.156	-0.04 – 0.27
	Working Full/Part Time [b]	-.087	.077	-0.48 – 0.32
Modifiable Factors	**Self-rated Health**	.111	.026	0.02 – 0.32
	Resilience	.065	.262	-0.07 – 0.27
	Depressive Symptoms	.354	<.001	0.05 – 0.10
	Social Support	-.143	.005	-0.03 – -0.01
	Subjective Wellbeing	-.193	.001	-0.53 – -0.13
	Food Secure [b]	.010	.844	-0.25 – 0.30
	Personal Financial Wellbeing	.007	.905	-0.07 – 0.07

***$p \le .05$ **$p \le .001$**

Note.
Factors were included based on theoretical and statistical reasoning and differ among models.
[a] Only non-modifiable factors were entered on Step 1. For parsimony, specific beta coefficients are presented only for Step 2.
[b] This variable is a dichotomous dummy variable compared to the reference group (eg, "Ages 18-29" compared to "all other ages" and "Female" compared to "male").

havior was negatively associated with higher self-rated health and being food secure.

Regarding Model 3, non-modifiable factors explained 6.8% of the variance in fruits/vegetables intake (Step 1). However, when adding modifiable factors into the model (Step 2), it explained an additional 6.6% of the variance (Table 4). Being female was associated with lower intake of fruits/vegetables. Participants who were between the ages of 18 and 29 also had lower intake of fruits/vegetables compared to participants in other age categories. Modifiable factors positively associated with greater fruits/vegetables intake included higher total METs per week and greater social support.

Regarding Model 4, non-modifiable factors explained 7.2% of the variance in added sugar intake (Step 1); when adding modifiable factors to the model (Step 2), it explained 3.2% of the variance (Table 4). Being female was associated with lower added sugar intake. Higher self-rated health was associated with having lower added sugar intake.

Regarding Model 5, whereas non-modifiable factors explained 7.9% of the variance in social isolation (Step 1), adding modifiable factors explained 20.7% of the variance (Step 2) (Table 5). Each increase in depressive symptoms was associated with increasing social isolation. Similarly, with each increase in self-rated health, social isolation increased. Higher subjective wellbeing and social support was associated with lower social isolation. Being Black was associated with increased risk of social isolation.

DISCUSSION

In this study, we provide initial insights into perceived changes that have occurred in daily life during the COVID-19 pandemic. In alignment with our hypotheses about the effects of COVID-19 on health behaviors (RQ1), participants reported a significant decrease in physical activity and increase in sedentary behavior and social isolation after COVID-19 restrictions were implemented/recommended. There were no perceived changes in diet quality. Echoing recent research,[50,51] and as theorized, our findings demonstrate how COVID-19 has created a change for many people, leading to potential trajectories of increased physical inactivity, subsequent adverse health outcomes, and substantial costs to the healthcare system.[5] We collected data as most states were starting to relax stay-at-home or shelter-in-place recommendations (reopening ranged from April 24 to June 19) after initiating restrictions between March 19 to April 7. Thus, we were able to capture perceived changes in behavior at the height of COVID-19 restrictions.[80]

There were no statistically significant associations between geographic location and physical activity, even though previous research indicated rural residents were least likely to meet physical activity recommendations.[14] We speculate that geographic location may be less relevant during COVID-19 because of restricted access to facilities. Similarly, the associations between unemployment and physical activity were not statistically significant. However, because unemployment has continued to rise in the US during the pandemic, it will be critical to continue to monitor unemployment effects on health behaviors. Being Black was significantly associated with lower physical activity but also less sedentary behavior. Additional research is required to uncover underlying contextual mechanisms. Lower rates of physical activity and lower sedentary behavior may be attributed to the measurement of specific types of activity, and not measuring time spent in other behaviors, or may indicate that targeted interventions to increase physical activity may be beneficial.

Those who reported greater food insecurity also engaged in more minutes of sedentary behavior during the current COVID-19 climate. Although food insecurity has been identified as a risk factor for physical inactivity, it is not commonly assessed in relation to sedentary behavior, particularly among adults.[81] We found sedentary behavior significantly increased after COVID-19 restrictions were implemented/recommended and 38% of participants experienced food insecurity within the past month. This is substantially higher than the 11% reported nationally in 2018.[82] These findings are concerning and suggest further monitoring is necessary.

Intake of fruits, vegetables, and added sugar did not significantly change after COVID-19 restrictions were implemented/recommended. This suggests people may be maintaining a consistent diet through uncertain times. In comparison to the US Dietary Guidelines, the average intake of fruits/vegetables was below and intake of added sugar was above (based on a 2000 kcal diet) the recommendations, which is concerning as adequate diet quality may be essential in the prevention of mortality due to COVID-19.[20,83]

The positive relationship between total METs and fruit/vegetable intake indicates healthier behaviors may cluster together, and therefore, supporting positive physical activity behaviors also could increase fruit/vegetable intake. In addition, as social support increased, fruit/vegetable intake increased. Thus, increasing social support may increase diet quality while also encouraging physical activity. Interestingly, other than sex, there were no demographic characteristics or health behaviors associated with sugar intake. The finding that women consume fewer fruits and vegetables, and less added sugar than men is inconsistent with previous literature. One possible explanation is that the context of COVID-19 may be altering typical health behaviors in novel ways. Alternatively, this could be attributed to the scoring procedures used for the DSQ which does not account for intake per calories consumed.[67] Within the context of rising unemployment, the lack of an association between food insecurity and diet quality was unexpected, as food insecurity is an established risk factor for diet quality.[25] Possible explanations for a lack of association between food insecurity and diet quality include effectively managing food resources or using other resources (eg, food banks).

The experience of social isolation among participants significantly increased, likely due to the implementation/recommendation of physical distancing. Being older was not significantly associated with social isolation, which was somewhat unexpected as there is a considerable focus in the gerontological literature on older adults' vulnerability to social isolation.[84] These findings challenge other findings suggesting isolation has not changed since COVID-19,[59] yet confirm older adults have been less vulnerable to physical distancing. One potential explanation for this may relate to how older adults tend to have fewer, but stronger social ties compared to their younger counterparts.[85] Thus, as individuals age they may be more resilient to changes in the size of, and contact with, their social network.

These findings suggest social isolation significantly increased for adults in each developmental stage within the context of COVID-19, including for individuals not typically considered at risk who may benefit from intervention. Several factors were consistent with extant literature including Black race, depression, lower wellbeing, and less social support being associated with increased social isolation.[35,45,49] Depression and subjective wellbeing had the strongest association with social isolation. This is concerning as the sample reported a high number of current depressive symptoms and a significant decline in wellbeing from the time prior to the introduction of COVID-19. Set point theory posits subjective wellbeing remains within a set range for adults but may change temporarily during a major life event.[86] Data collection occurred during a time of abrupt change as physical distancing was widely implemented/recommended across the US, which may account for decreases in wellbeing. Whether wellbeing will return to the original set point range as participants become accustomed to co-existing with the virus is unknown and longitudinal studies are needed. The association between higher self-rated health and social isolation was unexpected as social isolation is associated with numerous negative health conditions.[7,34] Within the context of COVID-19, however, it may reflect those with higher self-rated health were more likely to engage in physical distancing to preserve their health, and thus, experienced higher levels of social isolation.

Strengths and Limitations

Whereas it is somewhat expected that perceived changes in health behaviors occur during major societal upheavals, this study contributes knowledge about how these changes are occurring during the early phases of COVID-19 pandemic in the US and contributes to the scientific literature being created about the impacts of COVID-19. We collected data from a nationally representative sample of US adults and obtained a modest sample to begin to understand the perceived effects of COVID-19 during the height of the COVID-19 restrictions. Due to the modest sample size, and recruitment of only English speakers, we were unable to detect potential differences between ethnic groups, non-English speakers, or differences between sexes within ethnic groups. We used validated measures and included attention checks to ensure quality data collection. Because we used a cross-sectional survey, we cannot determine causal relationships; rather, we identified statistically significant factors associated with positive and negative health behaviors using participants' self-reported prior (retrospective data) and current behaviors. Although there are limitations to using self-reported recall data, it allowed us to evaluate perceived change in behaviors since COVID-19. As the pandemic continues, longitudinal data is needed to better understand the impacts on health behaviors over time.

Implications

Our results suggest US adults decreased physical activity, increased sedentary behavior and social isolation, and maintained inadequate diet quality. Consequently, the impact of COVID-19 likely will extend long beyond the end of the pandemic. The decreases in behaviors that support health are concerning, as studies suggest healthy behaviors may be protective against COVID-19 morbidity and mortality. Given that nearly all individuals reported some type of negative behavior change, universal intervention strategies are indicated.

Structural inequalities, cumulative disadvantage, and higher rates of morbidity and mortality due to COVID-19 experienced by Blacks,[3] coupled with our findings, indicate targeted interventions to support physical activity and reduce social isolation are necessary. Declines in physical activity and increased social isolation among Blacks indicate short- and long-term effects of COVID-19 may continue to exacerbate long-standing health inequities. We suggest further research to continue to understand the causes of inequities associated with COVID-19 to inform the implementation of place-based initiatives, policies addressing structural vulnerabilities, and targeted interventions to prevent inequity, structural racism, and promote health equity among individuals living in the US.[87]

Interventions addressing social support may be effective for encouraging multiple positive health behaviors. Social support is associated with increases in physical activity [88] and diet quality[89] and promotes overall quality of life.[90] Similarly, the clustering of health behaviors identified in the current study suggests that encouraging social support could impact multiple behaviors. Effective interventions designed to address social support and reduce social isolation among older adults could be developmentally adapted to support health across the lifespan.[91] For example, among older adults, using technology has been identified as a potential mechanism to overcome social and spatial barriers contributing to social isolation[92] and is associated with lower perceived loneliness and greater social connection.[93] Therefore, combining the use of technology to decrease physical barriers, along with the scaling-out of effective interventions encouraging social support, has the potential to support healthier behaviors across the lifespan.

Substantial perceived changes in physical activity and social isolation since the introduction of COVID-19 are evident in the US adult population. Individuals of all ages would likely benefit from universal intervention targeting health behaviors during a pandemic. We propose COVID-19 also may exacerbate inequalities in health behaviors among vulnerable populations and suggest the need for targeted invention. To reduce potential long-term health impacts, interventions increasing social support may be a mechanism to promote physical activity, diet quality, and social isolation. To meet this need, we suggest scaling-out effective interventions with the same level of intensity in which physical distancing recommendations were implemented/recommended to mitigate detrimental long-term health outcomes.

Human Subjects Statement

The Washington State University institutional review board for human subjects research approved this research. We obtained informed consent from all participants.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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Supplemental Table
Pearson Correlation Matrix

Total MET per week	1											
Sitting mins per day	-.194**	1										
Fruits/Vegetables Intake (c)	.155**	-.069	1									
Added Sugar Intake (tsp)	-.049	.108	-.049	1								
Social Isolation	.024	.051	-.057	-.050	1							
# Children (< 18) in Household	.172**	-.086	.034	-.006	.044	1						
Self-rated Health	.184**	-.169**	.140*	-.172**	-.028	.000	1					
BRS Average	.121*	-.127*	.197**	-.055	-.264**	-.030	.234**	1				
Depressive symptoms	-.143**	.153**	-.114*	.119*	.468**	-.013	-.231**	-.526**	1			
Social Support	.021	-.102	.181**	-.149**	-.246**	-.021	.224**	.294**	-.236**	1		
Subjective wellbeing	.108*	-.158**	.099	-.056	-.397**	-.048	.206**	.466**	-.504**	.356**	1	
Personal Financial Wellbeing	.044	-.002	.147**	-.062	-.167**	-.059	.304**	.289**	-.351**	.161**	.378**	1

Note.
*** Correlation is significant at the .05 level (2-tailed).**
**** Correlation is significant at the .01 level (2-tailed).**

Supplemental Table
Spearman's Rho Correlation Matrix

Total METs	1.000																		
Sitting	-.338**	1.000																	
Fruits/ Vegetables Intake	.286**	-0.053	1.000																
Added Sugar Intake	-0.096	0.058	-0.021	1.000															
Social Isolation	-0.033	0.053	-0.034	-0.013	1.000														
Ages 18-29	-0.122*	0.057	-0.119*	0.116*	0.183**	1.000													
Ages 20-59	0.132*	-0.044	0.086	0.027	-0.078	-0.550**	1.000												
Ages 60+	-0.036	-0.002	0.014	-0.135*	-0.083	-0.312**	-0.622**	1.000											
Female	-0.162**	-0.036	-0.241**	-0.289**	0.069	0.003	-0.007	0.005	1.000										
White Race/ Ethnicity	0.031	0.131*	0.018	0.033	0.154**	-0.149**	-0.027	0.169**	0.026	1.000									
Black Race/ Ethnicity	-0.091	-0.164**	-0.091	0.001	-0.106*	0.049	0.023	-0.072	0.004	-0.597**	1.000								
Other Race/ Ethnicity	0.003	-0.029	0.050	-0.047	-0.078	0.125*	-0.003	-0.113*	-0.030	-0.553**	-0.122*	1.000							
Full/Part Time work	0.113*	0.044	0.068	-0.001	-0.132*	-0.113*	0.323**	-0.261**	0.002	-0.057	-0.028	0.091	1.000						
Married/ Partnered	0.025	0.015	-0.020	0.042	-0.099	-0.215**	0.113*	0.074	-0.098	0.103	-0.126*	-0.047	0.060	1.000					
Food Secure	0.091	-0.116*	-0.161**	-0.008	0.028	-0.088	0.131*	-0.067	0.082	-0.163**	0.156**	0.104*	-0.006	-0.099	1.000				
Rural	0.014	-0.063	0.001	-0.030	-0.015	-0.090	0.039	0.040	0.024	0.172**	-0.085	-0.134*	-0.107*	0.038	0.064	1.000			
Small Town/ City	-0.041	0.041	-0.052	-0.004	0.075	-0.040	0.040	-0.008	-0.021	-0.009	-0.016	0.003	-0.011	0.085	0.058	-0.164**	1.000		
Suburban	-0.036	-0.021	-0.014	0.103	0.014	0.032	-0.068	0.047	-0.002	-0.059	0.014	0.067	0.001	0.089	-0.092	-0.475**	-0.320**	1.000	
Urban	0.060	0.056	0.052	-0.094	-0.057	0.076	0.015	-0.089	-0.006	-0.086	0.076	0.046	0.108*	-0.204**	0.008	-0.265**	-0.178**	-0.517**	1.000

Note.
*** Correlation is significant at the .05 level (2-tailed)**
**** Correlation is significant at the .01 level (2-tailed)**